

STRUCTURES - PLANNING AND DESIGN

I. DESIGN SPECIFICATIONS

Except as modified below, the design of all highway bridges shall be governed by the latest edition of the LRFD Bridge Design Specifications of the American Association of State Highway and Transportation Officials and all current Interim Specifications issued by the Association (referred to as the AASHTO LRFD Specification).

Structural foundations shall be designed by the Service Load method of the 16th Edition of the AASHTO Standard Specifications for Highway Bridges, with current interims.

Highway bridges utilizing curved steel girders shall be governed by Part II (Load Factor Design Criteria) of the Guide Specifications for Horizontally Curved Highway Bridges published by AASHTO, with current interims, and all superstructure and substructure elements of these bridges shall be designed in accordance with the Load Factor method of the 16th Edition of the AASHTO Standard Specifications for Highway Bridges, with current interims.

Existing bridge members shall be evaluated in accordance with the AASHTO Manual for Condition Evaluation of Bridges, 2nd Edition.

Bridges constructed to carry railways shall conform to the latest edition of the Manual for Railway Engineering published by the American Railway Engineering and Maintenance-of-Way Association (AREMA), subject to the requirements of the railroad concerned.

VI. SEISMIC DESIGN, ANALYSIS & RETROFIT

A. Design Specifications

The AASHTO LRFD Specifications have *not* been adopted for the seismic design or analysis of Turnpike structures. The seismic design provisions for LRFD are currently under revision and will be issued as a guide specification in the near future.

Except as modified below, the seismic evaluation of all highway bridges shall be governed by Division 1A of the 16th Edition of the AASHTO Standard Specifications for Highway Bridges, with current interims. Within Division 1A, where references are made to Division I Design, the Load Factor Method shall be used. Where detailing requirements are indicated, Seismic Performance Category B shall govern.

In the absence of site-specific response spectra, response spectra shall be developed in accordance with the 1997 *NEHRP Recommended Provisions for Seismic Regulations for New Buildings* (BSSC, 1998a and 1998b). The complete map set, Maps 1 - 32, are used with 1997 *NEHRP Guidelines for the Seismic Rehabilitation of Buildings* (Applied Technology Council, 1997a and 1997b). Response spectra may be obtained by zipcode using the following html: <http://geohazards.cr.usgs.gov/eq/html/nehrrp.html>

It is also noted that site response evaluation (soil amplification) must be applied and shall also be in accordance with the 1997 *NEHRP Recommended Provisions for Seismic Regulations for New Buildings*.

B. General Considerations

The most common and significant cause of earthquake damage is ground shaking. In addition to ground shaking, seismic hazards can also include ground failure, liquefaction, lateral spreading, differential settlement and land sliding. Bridges shall be evaluated and proportioned to resist significant damage to such events. As such, two levels of earthquake shaking hazard shall be used to satisfy the basic safety objectives for all Turnpike structures: Functional and Safety Evaluation Event Levels (FEE & SEE).

Under the Functional Evaluation objective, immediate operation is required (following bridge inspection) and minimal damage is permissible. This hazard level has a 10% probability of exceedence in 50 years (return period of approximately 500 years).

For a bridge designated for a Safety Evaluation performance level, significant disruption to service is permissible as is significant damage and has a corresponding 2% probability of exceedence in 50 years (return period of approximately 2,500 years).

These performance objectives represent a rational approach to seismic retrofit as well as new design, and therefore will be used as a basis for evaluating performance of bridges subjected to the functional and safety evaluation level events.

C. Design Requirements

For the design of bridges carrying Turnpike traffic, two events shall be considered, having return periods of approximately 500 years and 2,500 years. Response Modification Factors (R) for the latter event are as follows:

Element	<u>R</u>
Wall type pier	2
RC pile bents	
<i>Only vertical piles</i>	3
<i>With battered piles</i>	2
Single Columns	3
Multiple Column bent	5

For the 500 year return period, Response Modification Factors for all substructure elements shall be 1.5.

For the design of local road bridges over the Turnpike, including State and Federal highways, the design shall be based on the lesser of the two events, unless the owner has a published policy which requires otherwise.

For the design of certain special bridges which the Authority deems to be “critical”, the design shall be based on the 2,500 year return event and $R = 1.5$ for all substructure elements.

Bridges that are single span or bridges with less than 25,000 square ft in deck area shall be designed using the NEHRP response spectra, while bridges that exceed 25,000 square ft in deck area require a site-specific evaluation.

Site-specific procedures may be used for any bridge, but shall be used where any of the following apply:

- The bridge is located on Profile Type E or F soils (as defined by NEHRP).
- A time history response analysis will be performed as part of the design / retrofit.

D. Retrofit Requirements

FHWA’s Seismic Retrofitting Manual for Highway Bridges shall be used as a guide regarding evaluation procedures and upgrade measures for retrofitting seismically deficient highway bridges. This document is currently provided online at:

<http://www.tfhrf.gov//seismic/document.htm>

Seismic retrofit of existing bridges differs greatly from the design of new bridges since remaining service life must be considered in establishing a consistent level of safety. The AASHTO LRFD code is based upon an average bridge service life of 75 years, and therefore, seismic retrofit hazard should be a function of this estimate of bridge life. The desired Life-Safety event is taken as 3% probability of exceedence in 75 years, resulting in a return period that is nearly identical to the 2% in 50 year event. Therefore, a consistent level of risk can be proportionally established between bridge retrofit and new design requirements based on a specific accounting of a bridge's remaining life.

Bridges that are single span or bridges with less than 25,000 square ft in deck area shall be retrofitted to resist the 10% in 50 year probability event (return period of approximately 500 years) using the NEHRP response spectra. Isolation strategies, if employed, shall be evaluated for the 2% in 50 year event (return period of approximately 2,500 years) for design and detailing of the isolation bearings.

Bridges that exceed 25,000 square ft in deck area should require a site-specific evaluation based upon both the Functional and Safety Evaluation Event Levels with approximate return periods of 500 years and 2,500 years respectively.

References:

Applied Technology Council, 1997a, *NEHRP Guidelines for the Seismic Rehabilitation of Buildings*, FEMA 273, Washington, D.C.

Applied Technology Council, 1997b, *NEHRP Commentary for the Seismic Rehabilitation of Buildings*, FEMA 274, Washington, D.C.

Building Seismic Safety Council, 1998a, *NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures, Part 1 - Provisions*, 1997 Edition, FEMA 302, Washington, D.C.

Building Seismic Safety Council, 1998b, *NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures, Part 2 - Commentary*, 1997 Edition, FEMA 303, Washington, D.C.